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Domaining of downhole geochemical data – an automated approach applied to the Northern Limb of the Bushveld Complex

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The Northern Limb (NL) of the Bushveld Complex is host to some of the largest platinum-group element (PGE) deposits in the world, however there is limited understanding of the precise controls on the style and spatial distribution of mineralisation. Geochemical domains can be used as an initial step in understanding magmatic processes and for generating 3D orebody models, however the interpretation of domains and where boundaries should be placed can be subjective and time consuming when interpreting many drillholes. Boundary detection methods using continuous wavelet transforms (CWT) were first used in the geosciences to identify boundaries in downhole geophysical data [1]. Further developments to the methodology now allow for multivariate inputs, and have improved visualisation of the CWT scalogram [2], enabling easy interpretation of boundaries across multiple spatial scales of observation. This work shows how the multiscale, multivariate CWT method can be effectively used to domain downhole bulk geochemical data from a series of exploration drillholes from the NL to facilitate repeatable domaining that takes downhole spatial continuation into consideration. The attributes describing these domains can then be clustered to allow for spatial correlation across drillholes. The results of this workflow are shown to be a good comparison to results of manual geochemical domaining on NL drillhole data as performed by a geologist (figure 1), with the additional benefit of minimising human bias, enabling (re)interpretation of drillhole data with increased speed, and the ability to use different inputs to identify domains for specific purposes or at different scales of observation. Given the method relies on identifying inflection points in the data (rather than absolute values) to determine boundaries, this study also investigates the application of this method on portable XRF data which is typically biased and noisy.

[1] Cooper, G.R.J. & Cowan, D.R. (2009). Blocking geophysical borehole log data using the continuous wavelet transform. *Exploration Geophysics* 40, 233–236.

[2] Hill, E.J. & Pearce, M.A., Stromberg, J.M. (2021). Improving Automated Geological Logging of Drill Holes by Incorporating Multiscale Spatial Methods. *Mathematical Geosciences* 53, 21–53.

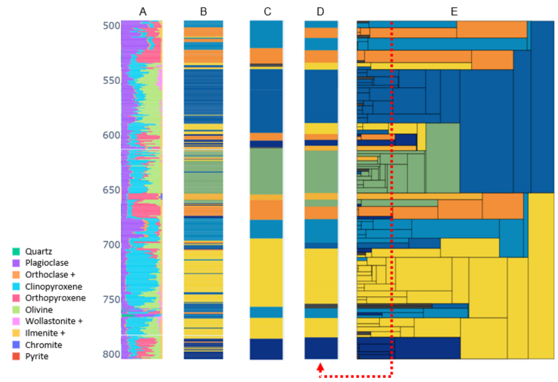

Figure 1. Example of automatically generated domains ('Pseudo Log') compared to manually interpreted domains. Column A shows the downhole normative mineralogy. Column B shows results of K-Means clustering on the centered log ratio normative mineralogy at the sample scale. Column C shows manually interpreted domains, coloured by the modal k-means class. Column D is a 'pseudo log' extracted from the multiscale domain mosaic in column E.